1984 AGU Spring Meeting Call Update, page 14

WaterWatch, page 9

Eos
Transactions, American Geophysical Union
Vol. 65 No. 2 January 10, 1984

Eos, Transactions, American Geophysical Union   Vol. 65, No. 2, Pages 9–16   January 10, 1984

Particles and Fields—Magnetosphere

Physical Properties of Rocks

Seismology

Social Sciences

Tectonophysics

Information Related to Geographic Region

News

In Congress

NOAA Budget Set

In late November, President Ronald Reagan signed into law the National Oceanic and Atmospheric Administration (NOAA) budget, which is part of the appropriations bill for the Departments of Commerce, Justice, State, the Judiciary, and related agencies; at the same time, he also signed into law an amendment attached to that bill that prohibits the sale of the weather satellites (*Eos*, May 17, 1983, p. 377, and March 22, 1983, p. 113). Commercialization of the land remote sensing satellite system is still being considered, however.

As a result of the conference between the House of Representatives and the Senate appropriations committees, the appropriation for NOAA totals $1020.6 million, with a program level of $1073.1 million. The appropriation is the money that comes from the federal treasury; the program level represents all of the funds—including treasury funds, transfers, residuals, etc.—actually available for the program. Strictly in terms of dollars, the total fiscal 1984 NOAA appropriation is almost level with the fiscal 1983 appropriation of $1000.9 million. In fiscal 1984, NOAA's research core, called Operations, Research, and Facilities (ORF), receives an appropriation of $988.2 million, with a program level of $1014.8 million.

Table 1 compares the 1983 base, the Reagan budget proposal, and the final conference program levels for ORF. The 1983 base, which is a conservative estimate of spending, is lower than the actual 1983 expenditures, which were being calculated as *Eos* went to press.

The satellite and environmental data and information services activity gets the biggest dollar increase, much of which goes to maintaining various satellite systems. Included in the increase for the satellite systems subactivity is an additional $20.4 million for the launch of Landsat D'; President Reagan added these funds to his initial budget request. Funding for data and information services, however, drops to a program level of $22.8 million.

Most of the increase for atmospheric programs, which accounts for more than one-third of ORF funds, goes to the public warning and forecast services subactivity. Within this subactivity, $10 million is slated for NEXRAD, the next generation weather radar system to improve severe weather forecasting (*Eos*, June 14, 1983, p. 411). Like the funds for the Landsat D' launch, this $10 million was amended to the president's initial request.

In the ocean and coastal programs activity, Congress restored funds to the Sea Grant program, which President Reagan had proposed to eliminate. Coastal zone management, which was included in ocean and coastal programs in the Reagan budget request, was removed entirely from ORF by Congress and established as a separate account.

The appropriations bill for Commerce, Justice, State, the Judiciary, and related agencies (H.R. 3222) was signed into law (P.L. 98–166) on November 28 by President Reagan. The bill included a rider, attached on the bill's way through Congress, that prohibited the federal government from spending money to solicit bids to carry out the proposed sale of the meteorological satellites. When the bill reached his desk, Reagan had the option of rejecting the budgets for all of those agencies or signing the bill. He opted to sign. This blocks only the sale of the weather satellites; plans to sell the land remote sensing satellite system are still under way by the Source Evaluation Board on Civil Space Remote Sensing.—*BTR*

TABLE 1. NOAA Operations, Research, and Facilities Fiscal 1984 Budget, Program Level, in Thousands of Dollars

Activity	1983 Base[1]	Reagan FY84 Proposal[2]	Final Conference FY84[3]
Ocean and Coastal Programs			
Nonliving marine resources	3,032	1,761	3,761
Ocean research	35,434	23,452	39,181
Ocean services	15,764	13,237	15,271
Sea Grant	35,000	0	36,500
Coastal zone management	14,226	6,056	7,706[4]
Mapping, charting, & geodesy	45,289	72,619	46,089
Subtotal	148,746	117,125	148,508
Marine Fishery Resource Programs	146,431	92,444	147,518
Atmospheric Programs			
Public warning & forecast services	272,221	284,938	311,100
Atmospheric & hydrologic research	49,042	44,561	51,856
Subtotal	321,263	309,497	562,356
Satellite & Environmental Data & Information Services			
Satellite services	66,617	73,279	71,479
Satellite systems	106,500	117,381	157,761
Data & information services	25,639	22,313	22,783
Subtotal	198,756	212,953	252,023
Program Support	115,813	95,363	111,878
Total, ORF	931,068	827,372	1,014,777

Source: NOAA. Numbers may not total because of rounding.
[1]The 1983 base is an estimate of 1983 spending. Actual expenditures are higher.
[2]See *Eos*, February 15, 1983, p. 65.
[3]Reflects congressional deliberations (see *Eos*, September 13, 1983, p. 548). The conference was completed October 31 and final approval was granted on November 18. The appropriations bill (H.R. 3222) was signed into law (P.L. 98–166) on November 28.
[4]Although the Reagan proposal includes Coastal Zone Management (CZM) in Ocean and Coastal Programs, Congress moved it into a separate account outside of ORF. The final conference ORF total does not include CZM.

December Streamflow

The high streamflows of recent months in the West eased somewhat during December, but streamflows increased in much of the eastern United States, setting many record or near record high flows in several states, according to the monthly check on national water resources conditions by the U.S. Geological Survey (USGS).

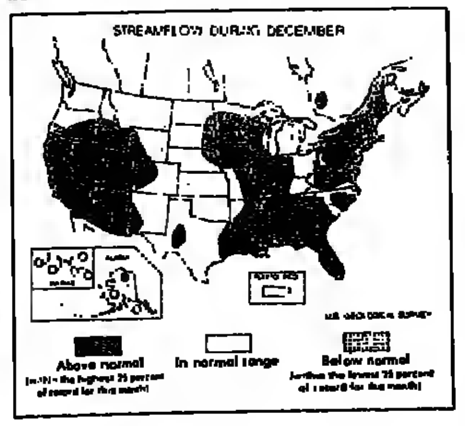
USGS hydrologists said that record or near record high average streamflows for the month were set at 36 stations in 24 states from Georgia to Alaska. In contrast to the many historic high flows, reports of low streamflows were isolated and unusual, with most low flows occurring between the Mississippi River and the Rocky Mountains and in the Pacific Northwest (see map, courtesy USGS).

Of the 173 key USGS gaging stations surveyed across the country, 127 (73%) reported streamflows well above average (in the highest 25% of record), 33 stations (19%) reported flows in the normal range, while only 13 stations (7%) were in the lowest 25% of record.

Reflecting the widespread and extremely wet conditions nationwide during December, the combined flow of the nation's three major rivers—the Mississippi, St. Lawrence, and Columbia—was 3937 billion liters per day (bld) (866 billion gallons per day), 68% above the long-term December average, and 64% greater than the combined flow in November. These three major rivers provide a useful check on the nation's water resources because they drain more than half of the conterminous United States.

Groundwater levels across the nation tended to be higher in December, largely in response to above-normal precipitation. Wells reached record high levels for December in New York, Connecticut, Maryland, Maine, and Nevada. Indicating the variability in the response of groundwater levels to local conditions, single wells in Maine and Nevada also set record low levels for the month.

Individual flows of the so-called "Big Five" rivers for December were as follows: the Mississippi River at Vicksburg, Miss., 2882 bld, 107% above average and 137% more than the flow in November; the St. Lawrence River near Massena, N.Y., 777 bld, a decline of 2% from November, but 11% above the monthly average; the Columbia River at The Dalles, Ore., 277 bld, a decline of 28% from November, but 9% above the long-term December average; the Ohio River at Louisville, Ky., 532 bld, or 40% more than the long-term monthly average, and an increase in mean flow of 77% from the previous month; and the Missouri River at Hermann, Mo., 245 bld, 107% above the usual December readings, but down 19% from the November flow.



Geophysicists

Jeffrey Alt, a student at the University of Miami's Rosenstiel School of Marine and Atmospheric Science, recently was awarded the Koczy Fellowship, given to a doctoral student at the school who has displayed "exemplary scholastic and research ability." His dissertation focuses on the mechanisms of submarine hydrothermal systems and on the role that hydrothermal alteration of the oceanic crust plays in regulating seawater composition.

Kimberlee Miskell, a student in marine geology and geophysics at the Rosenstiel School, has been awarded the 1983 Dean's Prize for the year's outstanding master's thesis. Her thesis is entitled "Accumulation of Opaline Silica in Deep Sea Sediments from the Mid-Cretaceous to the Miocene: a Paleocirculation Indicator."

Also at the Rosenstiel School, ***Alina Szmant-Froelich*** has been appointed a member of the faculty. Next spring she will continue her studies of coral reef energetics and nutrient dynamics at the Hydrolab in the U.S. Virgin Islands.

Peter Angus-Leppan, head of the school of surveying at the University of New South Wales in Sydney, Australia, has been awarded a senior scientist grant by the U.S. National Academy of Sciences' National Research Council. The grant will enable him to undertake geodesy research with the U.S. National Geodetic Survey. Angus-Leppan also was recently elected president of the International Association of Geodesy for 1983–1987.

Anton L. Inderbitzen is the new associate chief scientist of the Polar Science Division, Division of Polar Programs, in the National Science Foundation.

Recent Ph.D.'s

Eos periodically lists information on recently accepted doctoral dissertations in the disciplines of geophysics. Faculty members are invited to submit the following information on institution letterhead, above the signature of the faculty adviser or department chairman:

(1) the dissertation title.
(2) author's name.
(3) name of the degree-granting department and institution.
(4) month and year degree was awarded.

If possible include the current address and telephone number of the degree recipient (this information will not be published).

Many dissertations, including those with order numbers, are available from University Microfilms International, Dissertation Copies, P.O. Box 1764, Ann Arbor, MI 48106.

Applications of Hydrologic Modeling to Water Resource Assessment (Connecticut), Michael J. Brown, Harvard Univ., 1983 (GAX83-22310).

Biogeochemistry of Manganese and Iron in the Pacific Ocean, William M. Landing, Chemistry Dept., Univ. of California at Santa Cruz, June 1983.

Causation and Variability of the Northern Winter Quasi-Stationary Planetary Waves, David A. Jacqmin, Harvard Univ., 1983 (GAX83-23377).

Clear Atmospheric Effects on Insolation Illustrated by Broad-Band Radiometer Measurements (Washington, Mt. St. Helens), Daniel W. Spencer, State Univ. of New York, Albany, 1983 (GAX83-22620).

Depositional and Diagenetic Environments of Carbonate-Siliciclastic Rocks of the Glen Dean Formation (Upper Mississippian), Illinois Basin, U.S.A., Sadat Feiznia, Univ. of Illinois, Urbana-Champaign, 1983 (GAX83-24547).

Effect of Asymmetric Ekman Dissipation on Finite-Amplitude Baroclinic Disturbance, Shih-Hung Chou, Dept. of Atmospheric Science, State Univ. of New York at Albany, December 1983.

Generation and Characterization of Particulate Aerosols From Virgin Carbon Fibers and Composites, Richard J. Chang, Univ. of Arkansas, 1983 (GAX83-22962).

Interpretation of the Aeromagnetic Data Covering Portion of the Damara Orogenic Belt, With Special Reference to the Occurrence of Uraniferous Granite, Branko Corner, Univ. of Witwatersrand (South Africa), 1983.

Migration of Reflection Seismic Data in Angle-Midpoint Coordinates, Richard A. Ottolini, Stanford Univ., 1983 (GAX83-20760).

Moisture and Heat Transport, and Ocean Cooling Along the Track of a Moving Storm, Sami F. Al-Fahed, Catholic Univ. of America, 1983 (GAX83-24404).

Numerical Investigation of the Formation of Secondary Vortices in Laboratory-Simulated Tornadoes, Robert L. Walko, Univ. of Arizona, 1983 (GAX83-24466).

Paleomagnetism, Rock Magnetism and Diagenesis in Hemipelagic Sediments From the NE Pacific Ocean and the Gulf of California, Robert Karlin, Dept. of Geophysics, Oregon State Univ., November 1983.

Temperature and Axial Strain Rate Effects on Microcracking in Triaxially Compressed Marbles, Joseph K. Schrodt, Univ. of Illinois, Urbana-Champaign, 1983 (GAX83-24638).

Coastal Mining

The Exclusive Economic Zone (EEZ) declared by President Reagan in March 1983 has met with a mixed response from those who would benefit from a guaranteed, 200-nautical-mile (370-km) protected underwater mining zone off the coasts of the United States and its possessions. On the one hand, the U.S. Department of the Interior is looking ahead and has been very successful in safeguarding important natural resources that will be needed in the coming decades. On the other hand, the mining industry is faced with a depressed metals and mining market.

A report of the Exclusive Economic Zone Symposium held in November 1983 by the U.S. Geological Survey, the Mineral Management Service, and the Bureau of Mines described the mixed response as: ". . . The Department of Interior . . . raring to go into promotion of deep-seal mining but industrial consortia being very pessimistic about the program, at least for the next 30 or so years." (*Chemical & Engineering News*, February 5, 1983).

The circumstances are not too different from those surrounding U.S.-sponsored ocean margin drilling programs. The government would like to spend the required effort now to lay the groundwork for future decades. The petroleum industry sees at least 1 or 2 decades of relatively cheap continental petroleum sources being available and would like to delay the huge costs of continental margin exploration.

Right now there are few if any confirmed economic mineral deposits within the EEZ. There are copper ores that are not being mined due to the depressed international market. Indeed, copper prices have not risen in almost 2 decades. The new extended zones will experience little actual mining activity until they are explored and evaluated. A serious factor in their development will be environmental protection. Lacking the costs of satisfactory environmental constraints, foreign-produced metals are proving to be much cheaper in the United States than domestically produced metals. Exploration, evaluation, and a working minerals policy will be key issues in the development future of EEZ ore deposits, but costly research and exploration in high-risk zones is not a high priority for mining companies because of the economic realities of world markets.

The EEZ legislation is a United States initiative not unrelated to the decade-long efforts to produce the Law of the Sea. The most important deposits originally envisioned for the Law of the Sea exploitation were for the most part manganese nodules. The mining of nodules is yet to be realized on a significant scale, and it may be some time before they can be dredged from the ocean floor economically. The more recent discovery of polymetallic sulfides associated with underwater hot springs has resulted in heightened efforts to protect national resources, and to extend potential mining zones. Whatever U.S. government plans may call for, however, ores requiring expensive mining procedures will not be competitive for the present. It is much more economical to import ores, metals, and indeed, finished products in the current market. The metals market in the United States is characterized, at least in the short term, by overcapacity.

Aside from metals, phosphorite deposits located within the EEZ may turn out to be the first exploited. A large percentage of mineral phosphates are used to make fertilizers, and unlike metals futures, the world demand for phosphates is expected to increase by 70% or more by the end of this century. Thus, there is a good chance that phosphate mining will move offshore by the end of the century. The United States, within the new zones, now has control of sizable deposits.—*PMB*

The VGP News

Editor: Bruce Doe, 11721 Bay River Court, Reston, VA 22091 (telephone 703-860-1170, after 5:30 p.m.)

A Relation Among Geomagnetic Reversals, Seafloor Spreading Rate, Paleoclimate, and Black Shales

Eric R. Force

The Mesozoic-Cenozoic histories of reversals in the earth's magnetic field and of periods of widespread anoxia in the ocean basins show a remarkable correlation (Figure 1): periods of black-shale deposition ("anoxic events") occur during lengthy periods without magnetic reversals ("quiet" periods). My assembly of published work indicates a remote connection between quiet periods and anoxic events and suggests its form: Magnetic quiet periods coincide with fast seafloor spreading. During these periods, buoyant spreading ridges displace seawater onto broad shelves, thus decreasing earth's albedo and causing global warming. Temperature gradients, and thus density gradients, from pole to equator decrease in surface waters, and the deep ocean currents of oxygenated polar waters wane. Oxygen minimum zones intensify and widen; anoxic conditions throughout entire basins are indicated by black shales deposited in the deep sea. These relations thus suggest that the earth's interior processes and its climate are related and their stamp recorded by both magnetic polarity and anoxic event chronologies of the earth. A test of the model for the Paleozoic is proposed and some implications for mineral resources noted.

Sheridan et al. [1982] noted an empirical link, based on both the Jurassic and Cretaceous quiet zones, between fast seafloor spreading and stable magnetic polarity. They suggested that erupting heat plumes couple activity of the outer core and lower mantle. The relationship between magnetic polarity and spreading rate is seen at several spreading centers (Figure 1).

The link between fast spreading and transgression is well established [*Hays and Pitman*, 1973]. Because newly generated oceanic crust cools and subsides as a function of time regardless of spreading rate, fast-spreading centers have a broad cross section (Figure 2). An increase in spreading rate thus displaces seawater onto continental shelves and into epicontinental seaways. Cretaceous high sea levels observed in sections on cratons correspond to times of fast spreading [*Hays and Pitman*, 1973; *Vail et al.*, 1977].

Calculations of the earth's albedo in the Cretaceous (with continents in their correct positions for the time) show that high sea levels and consequent larger oceans resulted in a significant albedo decrease [*Barron et al.*, 1980]. More solar energy was absorbed. However, estimates of the magnitude of warming are not yet possible because feedback factors such as cloudiness are poorly understood. Greater atmospheric CO_2 contents due to increased volcanism during times of fast spreading [*Berner et al.*, 1983] reinforced this effect. Warmer paleoclimates have long been observed from fossil assemblages and oxygen-isotope measurements (Figure 1) for roughly the Aptian to Campanian (mid-late Cretaceous) and the Middle to Late Jurassic [*Douglas and Savin*, 1975; *Frakes*, 1979; *Savin*, 1977; *Gordon*, 1974].

A decrease in the surface-temperature gradients from pole to equator is also observed by these authors from these time periods, i.e., the temperature increase near the pole was greater than that near the equator. These gradients are lower during warm periods because polar ice caps with high albedos retreat and because poleward transport of the latent heat of evaporated water increases [*Manabe and Wetherald*, 1980; *Kellogg*, 1979].

A link between low temperature gradients and ocean stagnation was proposed [*Schlanger and Jenkyns*, 1976; *Fischer and Arthur*, 1977] partly because of coincident timing of widespread black-shale deposition (anoxic events) and periods of equable climate. Compare the situation today with that in the Cretaceous; today's high temperature gradients (and some generation of saline waters by incongruent freezing) cause high density gradients in seawater and drive vigorous bottom currents from the poles. These currents today prevent significant ocean stratification; ocean-wide zones of strong oxygen-minima form only where bottom currents are weak e.g., the north Pacific [*Demaison and Moore*, 1980]. In the Jurassic and Cretaceous, low temperature gradients must have resulted in weaker bottom currents (though probably not in weaker surface and atmospheric circulation [*Barron and Washington*, 1982]). Bottom waters may have been generated in sub-tropical evaporative basins [*Thierstein and Berger*, 1979]. Strong oxygen-minimum zones became widespread. Intersections of oxygen-minimum zones with ocean floors are the sites of black shales penetrated in Deep Sea Drilling Project (DSDP) holes and sections now on land (Figure 2); locally, black shales formed in silled basins also [*Thierstein and Berger*, 1979]. The timing of black-shale deposition is shown as anoxic periods on Figure 1.

Periods of widespread anoxia are of economic importance because the organic precursors of petroleum were preserved in sediments [*Arthur and Schlanger*, 1979]. These periods also saw formation or preservation of some metal deposits [*Cannon and Force*, 1983; *Force et al.*, 1983], due to strong solubility contrasts between anoxic and oxygenated water. For example, massive polymetallic sulfides that formed on ocean floors during anoxic periods have probably been selectively preserved (Figure 2).

Other authors have assembled some of the same links to form other models [e.g., *Keith*, 1982]. The models most similar to the one in this paper is *Fischer* [1981] and *Sheridan* [1983].

Genetically related events should be similarly spaced in time, and this spacing has not been shown yet across the spectrum of linkages proposed here. Mesozoic changes of spreading rate are presently documented only over time periods of about 10–30 m.y., whereas anoxic periods and their associated sea level fluctuations (third-order fluctuations of *Vail et al.* [1977]) occupy 3–10 m.y. (Figure 1). Currently available spreading-rate histories for the Mesozoic are very crude, however. In order to see whether hidden changes in spreading rate could plausibly result in observed 3–10 m.y. fluctuations, I calculated "backward" to determine a spreading-rate increase which could result in a sea level rise of 100 m in 5 m.y. Present total length of ridges (58,750 km), cylindrical ocean basins, and present areas of oceans and of land areas 0–100 m in elevation were assumed. The increase required is about 2.1 cm per year half rate for all ridges, or about 12–70% of observed average spreading rates for ridges listed by *Hays and Pitman* [1973] for the Cretaceous magnetic quiet interval. This rate seems possible, and therefore changes in spreading rate might indeed cause 3–10 m.y. sea-level fluctuations. The question of regression rate was not addressed. *Schlanger et al.* [1981] record midplate seafloor volcanism and raised seafloors from the Cretaceous; these factors (and ridge proliferation) are probably related to spreading rate changes, and potentially lessen the magnitude of increased spreading rate needed to produce transgression.

With oriented DSDP cores, testing of this hypothesis by rendering the sequence of events within single cores should be possible. Onset of anoxic bottom conditions should not precede magnetically quiet intervals (unless the model is backwards!).

If this hypothesis has genetic significance, it should hold regardless of when the specified conditions occurred. Periods of widespread anoxia have been proposed for the Paleozoic, from black shale sections on land alone because no intact ocean floor remains [e.g., *Leggett*, 1980]; these sections should not contain magnetic reversals in those portions showing carbon-isotope records of open-ocean anoxia.

Numerous other tests of the model would see how well one factor predicts another; if results are positive, some of these tests could develop into mineral-exploration techniques (for example, a link between magnetic polarity and some sedimentary minerals).

Many of the linkages proposed here are matters of dispute or incomplete work, so errors in my depiction are likely. Nevertheless, the accord with observed features of earth history across the entire spectrum of linkages, and the similarity of the "signals" recorded by magnetic reversals and anoxic periods are indications that the general form of the hypothesis is correct. If so, a connection exists between processes in the earth's interior which produce its magnetic field and climatic response at its surface.

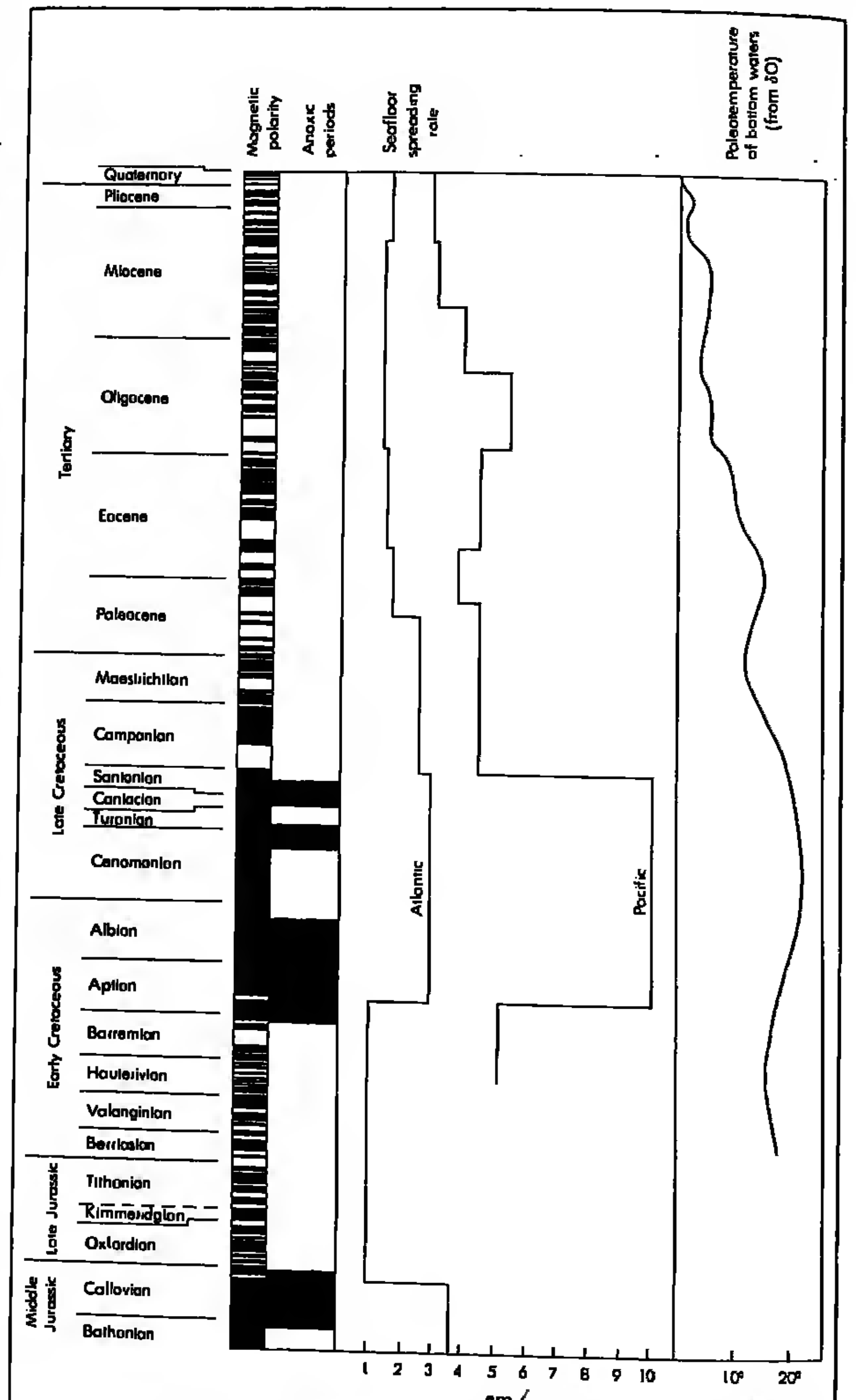


Fig. 1. Comparison of magnetic polarity time scale [*Larson et al.*, 1982] with periods of widespread anoxia [*Arthur*, 1979], average half-rates of sea floor spreading (simplified from *Larson and Pitman* [1972]; and *Sheridan et al.*, [1982]) and oxygen isotope-derived bottom paleotemperatures from the north Pacific [*Douglas and Savin*, 1975]. The presence of all the chronologies in a single data set (cores of the DSDP), minimizes systematic offsets, but detailed correlation is still a problem.

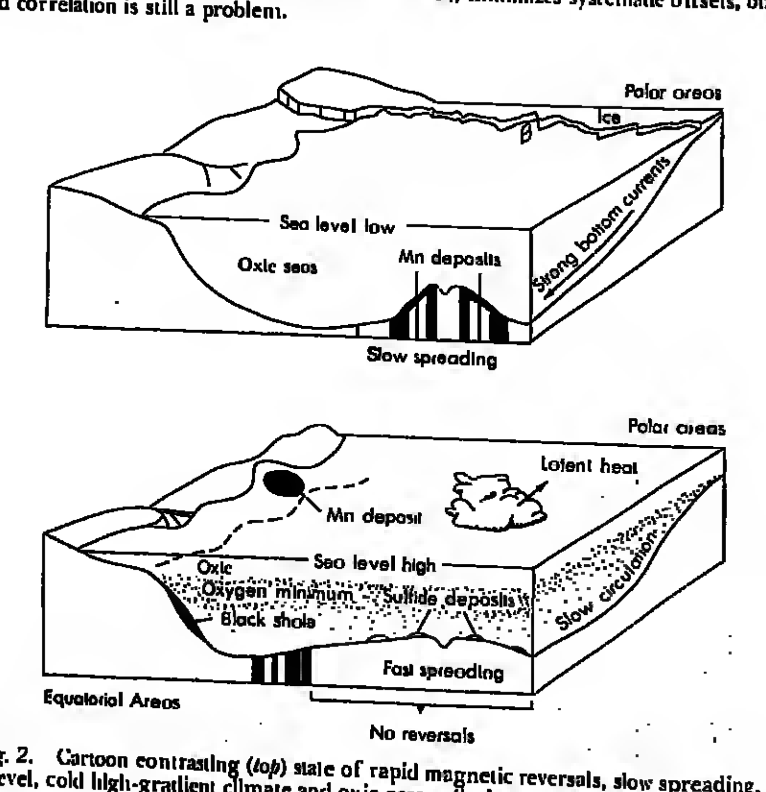


Fig. 2. Cartoon contrasting (*top*) state of rapid magnetic reversals, slow spreading, low sea level, cold high-gradient climate and oxic oceans (icehouse state of *Fischer* [1981]) and (*bottom*) state of magnetic quiet, fast spreading, high sea level, warm low-gradient climate and dysaerobic oceans (greenhouse state). Degree of oxygen depletion proportional to stippling; oxygen minimum zones would intersect only seamounts, plateaus, and basin margins in the deeper Pacific.

I am indebted to W. F. Cannon, R. P. Sheldon, Louis Nicolaysen and others for discussions on the form of linkages and to L. W. Snee and Lisa M. Pratt for help in formulating the Paleozoic test. Suggestions by participants in the 1983 Penrose conference "Cretaceous Climates" are appreciated.

References

Arthur, M. A., Paleoceanographic events: Recognition, resolution, and reconsideration, *Rev. Geophys. Space Phys.*, *17*, 1474–1494, 1979.

Arthur, M. A., and S. O. Schlanger, Cretaceous "oceanic anoxic events" as causal factors in development of reef-reservoired giant oil fields, *Am. Assoc. Pet. Geol. Bull*, *63*, 870–885, 1979.

Barron, E. J., J. L. Sloan II, and C. G. A. Harrison, Potential significance of land-sea distribution and surface albedo variations as a climatic forcing factor; 180 m.y. to the present, *Paleogeog., Paleoclimatol., Palaeoecol.*, *30*, 14–40, 1980.

Barron E. J., and W. M. Washington, Cretaceous climate: A comparison of atmospheric simulations with the geologic record, *Paleogeog., Paleoclimatol., Palaeoecol.*, *40*, 103–133, 1982.

Berner, R. A., A. C. Lasaga, and R. M. Garrels, The carbonate-silicate geochemical cycle and its effect on atmospheric carbon dioxide over the last 100 million years, Am. J. Sci., *283*, 641–683, 1983.

Cannon, W. F., and E. R. Force, Potential for high-grade shallow-marine manganese deposits in North America, in *Cameron Volume on Unconventional Mineral Deposits*, Am. Inst. Min. Metall. Pet. Eng., New York, pp. 175–190, 1983.

Demaisson, G. J., and G. T. Moore, Anoxic environments and oil source bed genesis, *Am. Assoc. Pet. Geol. Bull.*, *64*, 1179–1209, 1980.

Douglas, R. G., and S. M. Savin, Oxygen and carbon isotopic analyses of Tertiary and Cretaceous microfossils from Shatsky Rise and other sites in the North Pacific, *Initial Rep. Deep Sea Drill. Proj.*, *32*, 509–520, 1975.

Fischer, A. G., Climatic oscillations in the biosphere, in *Biotic Crises in Ecological and Evolutionary Time*, edited by M. Nitecki, p. 101–131, Academic, New York, 1981.

Fischer, A. G., and M. A. Arthur, Secular variations in the pelagic realm in Deep-water Carbonate Environments, edited by H. E. Cook and P. Enos, *Soc. Econ. Paleontol. Mineral. Spec. Pub.*, *25*, 19–50, 1977.

Force, E. R., W. F. Cannon, R. A. Koski, K. T. Passmore, and R. B. Doe, Influences of ocean anoxic events on manganese deposition and ophiolite-hosted sulfide preservation, *U.S. Geol. Surv. Circ.*, *822*, 26–29, 1983.

Frakes, L. A., *Climates through Geologic Time*, 310 pp., Elsevier, Amsterdam, 1979.

Gordon, W. A., Physical controls on marine biotic distribution in the Jurassic period, in *Paleogeographic Provinces and Provinciality*, *Soc. Econ. Paleontol. Mineral. Spec. Publ. 21*, 136–147, 1974.

Hays, J. D., and W. C. Pitman III, Lithospheric plate motion, sea level changes, and climatic and ecological consequences, *Nature*, *246*, 18–22, 1973.

Keith, M. L., Violent volcanism, stagnant oceans, and some inferences regarding petroleum, strata-bound ores, and mass extinctions, *Geochim. Cosmochim. Acta.*, *46*, 2621–2637, 1982.

Kellogg, W. W., Influences of mankind on climate, *Annu. Rev. Earth Planet. Sci.*, *7*, 63–92, 1979.

Larson, R. L., and W. C. Pitman III, World-wide correlation of Mesozoic magnetic anomalies, and its implications, *Geol. Soc. Am. Bull.*, *83*, 3645–3662, 1972.

Larson, R. L., X. Golovchenko, and W. C. Pitman III, Geomagnetic polarity time scale in *Plate-tectonic map of the circum-Pacific region*, Am. Assoc. Pet. Geol., 1982.

Leggett, J. K., British Lower Palaeozoic black shales and their palaeo-oceanographic significance, *J. Geol. Soc., London 137*, 139–156, 1980.

Manabe, S., and R. T. Wetherald, On the distribution of climate change resulting from an increase in CO_2 content of the atmosphere, *J. Atmos. Sci.*, *37*, 99–117, 1980.

Savin, S. M., The history of the earth's surface temperatures during the past 100 million years, *Annu. Rev. Earth Planet. Sci.*, *5*, 319–355, 1977.

Schlanger, S. O., and H. C. Jenkyns, Cretaceous oceanic anoxic events: causes and consequences, *Geol. Mijnbouw.*, *55*, 179–184, 1976.

Schlanger, S. O., H. C. Jenkyns, and I. Premoli-Silva, Volcanism and vertical tectonics in the Pacific Basin related to global Cretaceous transgressions, *Earth Planet. Sci. Lett.*, *52*, 435–449, 1981.

Sheridan, R. E., Phenomena of pulsation tectonics related to the breakup of the eastern North American continental margin, *Initial Rep. Deep Sea Drill. Proj.*, *76*, 897–909, 1983.

Sheridan, R. E., et al., Early history of the Atlantic Ocean and gas hydrates on the Blake Outer Ridge: Results of Deep Sea Drilling Project Leg 76, Geol. Soc. Am. Bull., *93*, 876–885, 1982.

Thierstein, H. R., and W. H. Berger, Injection events in ocean history, *Nature*, *276*, 461–466, 1978.

Vail, P. R., R. M. Mitchum Jr., and S. Thompson III, Seismic stratigraphy and global changes of sea level, part 4: Global cycles of relative changes of sea level, *Am. Assoc. Pet. Geol. Mem.*, *26*, 83–97, 1977.

Eric R. Force is with the U.S. Geological Survey, Reston, VA 22092.

EOS

Transactions, American Geophysical Union

The Weekly Newspaper of Geophysics

For speediest treatment of contributions send three copies of the double-spaced manuscript to one of the editors named below and one copy to AGU.

Editor-in-Chief: A. F. Spilhaus, Jr.; Editors: Marcel Ackerman, Mary P. Anderson, Peter M. Bell (News), Bruce Doe, C. Stewart Gillmor (History), Clyde C. Goad, Arnold L. Gordon, Louis J. Lanzerotti, Robert A. Phinney; Managing Editor: Gregg Forte; News Writer: Barbara T. Richman; News Assistant: Tony Reichhardt; Production Staff: James M. Hebblethwaite, Dae Sung Kim, Patricia Lichiello, Lisa Lichtenstein, Cynthia T. McManigal.

Officers of the Union
James A. Van Allen, President; Charles L. Drake, President-Elect; Leslie H. Meredith, General Secretary; Carl Kisslinger, Foreign Secretary; J. Tuzo Wilson, Past President, A. F. Spilhaus, Jr., Executive Director; Waldo E. Smith, Executive Director Emeritus.

For advertising information, contact Robin E. Little, advertising coordinator, at 202-462-6903 or toll free at 800-424-2488. Advertising must be informative and consistent with the scientific and educational goals of AGU and is subject to approval by AGU. Advertisers and their agents assume liability for all content of their advertisements and for any claims arising therefrom against the publisher. Offers in advertisements are subject to all laws and are void where prohibited.

Views expressed in this publication do not necessarily reflect official positions of the American Geophysical Union unless expressly stated.

Subscription price to members is included in annual dues ($20 per year). Information on institutional subscriptions is available on request. Second-class postage paid at Washington, D. C., and at additional mailing offices. *Eos, Transactions, American Geophysical Union* (ISSN 0096-3941) is published weekly by

American Geophysical Union
2000 Florida Avenue, N.W.
Washington, DC 20009

Cover. Geological formation known as the Great Dike of Rhodesia extends from upper center to lower left in this photograph taken from space shuttle *Challenger* as it passed over Zimbabwe during the eighth shuttle mission, September 1983. Because of the shuttle's nighttime launch, the crew was able to photograph during daylight parts of Africa, the Amazon jungle, and the Australian desert that previous crews had seen only at night. (Photo courtesy of NASA.)

An Invitation

Would you like to be on the cover of *Eos*? If you have any illustrations with both aesthetic charm and scientific interest—photographs (preferably black and white) of geophysical phenomena, experimental results, or graphs—*Eos* would like to consider them for publication on the cover. Send the original illustration or 8 x 10 inch (20 x 25 cm) glossy photo with a short (50–200 words) explanation that can serve as a caption. You may also submit a more extensive news item or even a short article to accompany a proposed cover. Captions will be by-lined. If the material has been previously published, please supply a copyright release from the copyright owner. Send it to *Eos* Cover, AGU, 2000 Florida Avenue, N.W., Washington, DC 20009.

Meetings

Water in Silicate Melts

Water is one of the more important volatile species in magmas, both in terms of its abundance and its influence on the properties of a given magma. Many workers in the geological sciences have measured, modeled, and speculated on the interaction of water with silicate melts as a function of pressure. At the same time, glass and materials scientists have collected a considerable body of data on the effect of water on the properties of liquid and glassy silicates at 1 atmosphere (1.01325 x 10^5 N m^{-2}) and below. A special session on "Solubility and Transport Properties of Water in Silicate Melts" was held during the 1983 AGU Spring Meeting, May 30–June 3, in Baltimore. The session had three main objectives: (1) review the present data base and discuss the status of current models in order to identify areas where further work is needed; (2) introduce interested geologists to the large body of work being carried out in the glass and materials sciences; and (3) consider specific properties, such as thermodynamic relations, structure of hydrous melts, and dynamic properties including diffusion and viscosity. This report summarizes the major topics discussed. More detailed information may be found in the published abstracts (*Eos*, May 3, 1983, pp. 338–343).

The session opened with two papers setting the geological perspective of water solubility in magmas. J. Eichelberger and H. Westrich discussed the observed water content and distribution in obsidian flows, where the average observed water content reflects the solubility of water in rhyolite liquid at near 1 atmosphere pressure. They considered the effect of degassing on water distribution within observed flows, and on the water content of ejected material during explosive eruption. J. Clemens reviewed measured and estimated contents of water for a variety of andesitic to granitic rocks. He found melt-water contents between 0.7 and 7 wt % water depending on the sample and source conditions (but with a general average value near 3 wt %), and he discussed the relative merits of methods for estimating water content. J. P. Coutures and G. Urbain presented a survey of solubility results obtained by glass and materials scientists for silicate glasses and liquids near 1 atmosphere. These water solubilities generally fall around 0.05–0.2 wt %, with some possible systematics as a function of composition. Discrepancies between different data sets, however, preclude any detailed correlations at present.

P. McMillan and J. Holloway summarized some water solubility measurements on synthetic and natural silicate melts at high pressures. Again, some systematic behavior with composition was noted, but the present data base is too limited to explore this fully. E. Stolper, L. Silver, and R. Aines summarized their recent infrared spectroscopic work on the speciation of water in hydrous silicate glasses and presented the results of new studies at high temperature. They found that both hydroxyl and molecular water species coexist to at least 550°C, supporting their dissolution model for water in molten silicates.

The next two papers concerned modeling of thermodynamic relations for hydrous melts. D. Eggler considered the dissolution reaction of water in diopside melt, and discussed Henrian, Henrian analogue ($a = x^n$), and non-Henrian expressions for its activity-composition relations. A. Boettcher presented experimentally determined melting curves in the systems $NaAlSi_3O_8$-H_2O-CO_2 and SiO_2-H_2O-CO_2. He compared and contrasted mixing relations in the fluids and silicate liquids for these two systems. These data suggested that CO_2 is soluble in SiO_2 liquids at high pressures (greater than or equal to 15 kbar) and high water contents. Discussion which followed this general topic emphasized the useful thermodynamic descriptions for such hydrous systems need not be simply correlated with structural changes in the melt.

Four papers examined the diffusion of water in hydrous glasses and melts and the effect of water on diffusion of other species. M. Tomozawa described the importance of water in the glass sciences and then presented the results of several studies of water diffusion in silicate glasses. One interesting result was the large observed dependency of the diffusion coefficient on the stress regime in nonhydrostatic experiments at relatively low pressure and temperature.

Two papers by K. Lapham and J. Karsten reviewed water diffusion studies in silicate melts and glasses and presented some results of their recent studies on diffusion of water in obsidian. Observed variations in the diffusion coefficient with temperature and composition were summarized and current models for the "water" diffusion mechanism were discussed. Lapham noted no pressure dependence of the diffusion coefficient in her obsidian study, in contrast to that observed by M. Tomozawa. This difference may be partly due to the higher pressures and temperatures involved in the obsidian runs and perhaps the hydrothermal nature of these latter experiments.

T. M. Harrison and E. B. Watson discussed the effect of water content on the diffusion of zirconium in granitic melts. They found a large increase in diffusivity and solubility at higher water contents and discussed the effect of this on zircon dissolution kinetics in hydrous granitic magmas.

The afternoon poster session included a number of presentations directly related to the discussions in the morning.

From informal discussions before, during, and after the meeting, we feel that the following general conclusions may be drawn. First, there are relatively few published estimates for water contents of primary igneous magmas, and more solubility data are necessary for synthetic and natural compositions at both high and low pressures. Likewise, diffusion data as a function of pressure, temperature, and composition are needed. Second, empirical models of thermodynamic and dynamic properties of the melt are needed, especially for those interested mainly in calculation of the effect of water on bulk properties. At the same time, mechanistic studies at the molecular level will lead to a better understanding of water-melt interactions at the microscopic level. More spectroscopic studies are needed on hydrous glasses, and especially on hydrous melts at pressure and temperature. We feel that both empirical modeling and structural studies are worthwhile and should be pursued with as much interplay between the two approaches as possible.

This meeting report was prepared by Paul McMillan, who is with the Department of Chemistry, Arizona State University, Tempe, AZ 85287 and Edward Stolper, who is with the Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91109.

Books

Geophysics in the Affairs of Man: A Personalized History of Exploration Geophysics and its Allied Sciences of Seismology and Oceanography

C. C. Bates, T. F. Gaskell, and R. B. Rice, Pergamon, Oxford, xx + 492 pp., 1982, $25.

Reviewed by Carl Kisslinger

This book traces the development of the applications of the geophysical sciences to a variety of societal needs from their beginnings to now, with emphasis on the "golden age," the early 1920's through the 1960's. The phrase "applied geophysics" is so often taken as synonymous with "geophysical exploration" that the broader viewpoint of this work is especially welcome. The authors certainly devoted much of their treatment to exploration geophysics, as is appropriate in view of the large commitment of human and financial resources to this endeavor and the practical importance of the results. However, they have also included interesting sketches of military applications of geophysical techniques and the important technological advances that have come from these, as well as much material on ocean science. Atmospheric and space science receives less detailed coverage.

The opening chapter, historical background to the developments of the 20th century, is brief, incomplete, and uneven in its coverage. An adequate treatment could well have doubled the size of the book, but some landmark developments that I looked for are missing. The heart of the book is the decade-by-decade story of each of the major themes (exploration, ocean science, global seismology) from the end of World War I through the 1970's. The story is told in terms of the personalities who built the subjects and the events that shaped their progress. It was fun to read this review and interpretation of one's teachers and friends. This is a humanized history of the grand projects that have moved geophysics ahead, the key technical developments along the way and the interplay of the creative minds responsible for progress.

The origins of seismic exploration for oil are explored, with emphasis on developments in the United States but with a fair treatment of European contributions. Gravity and magnetic methods are treated in less detail. The parallel growth of earthquake seismology and oceanography in the 1930's is presented in terms of the leaders who emerged and the institutions that nurtured the efforts.

The enormous impact of World War II on technical and theoretical developments important to geophysics follows. The progress in all areas in the postwar period is highlighted by the story of Project Vela-Uniform, the search for methods to *monitor* underground nuclear tests that jerked seismology into the modern era within a few years, beginning in 1959. The continuation of this effort to the present is a theme through the rest of the book. Progress and the new leadership that emerged in the 1970's and 1980's are not treated in any detail. The commercial aspects of exploration geophysics, a big business indeed, are also explored in a personalized way through the stories of a number of the companies, large and small.

The tale rambles a bit along the way and the authors get immersed in great detail in places where they are talking about topics with which they have been closely associated. As a reader who cannot ignore a footnote, I found the flow of the text interrupted continuously by the need to drop to the bottom of the page for the ancillary information offered. I was amused by the penchant for military titles used throughout (Rear Admiral Lloyd Berkner, USNR; Lieutenant "Jimmy" Carter, USN [Retired]).

I liked very much the personal evaluations by a number of well-known geophysicists of their own achievements and experiences. The book closes with this section, which should help remind today's students that the advancement of science, including triumphs and blunders, results from the efforts of people very much like themselves.

The authors have some strong prejudices that come through clearly in places. They don't like "environmentalists" and they take a dim view of a variety of national social programs of the recent past, including affirmative action in its various forms. I think that the kind of sarcastic assault on the environmentalist movement in the first part of chapter 7 has an effect similar to that of James Watt: The true believers perceive the need to circle the wagons more closely and dig in deeper. The authors do mention some of the outstanding women and minority-group members who have been leaders in the fields covered, but the fact remains that the number of such people is very small. I think that as a history of applied geophysics, the book would have been better without these elements, but here my *own* prejudices are showing clearly.

The book is a useful source of background on people and events that stimulated the growth of important parts of the geophysical sciences. It is especially important because it reminds us of the long-term effects on whole areas of human endeavor of isolated and apparently unrelated events.

Carl Kisslinger is with the Cooperative Institute for Research in the Environmental Sciences at the University of Colorado, Boulder, CO 80309.

New Publications

Items listed in New Publications can be ordered directly from the publisher; they are not available through AGU.

Air-Sea Exchange of Gases and Particles, P. S. Liss and W. G. N. Slinn (Eds.), D. Riedel, Boston, xiii + 561 pp., 1983, $69.50.

Changing Climate: Report of the Carbon Dioxide Assessment Committee, Board on Atmospheric Sciences and Climate, Commission on Physical Sciences, Mathematics, and Resources, National Research Council, National Academy Press, Washington, D. C., 1983, $29.95.

Deformation Measurements, I. Joo and A. Detrekoi (Eds.), Akademiai Kiado, Budapest, xxii + 900 pp., 1983, $59.

Earthquakes, Tides, Unidentified Sounds, and Related Phenomena: A Catalog of Geophysical Anomalies, Compiled by W. R. Corliss, The Source Book Project, Glen Arm, Md., 1983, $12.95.

Earthquakes, Volcanoes, and Tsunamis: An Anatomy of Hazards, K. V. Steinbrugge (Ed.), Skandia Corp., xv + 392 pp., 1982, $35.

Eddies in Marine Science, A. R. Robinson (Ed.), Springer-Verlag, New York, xxv + 609 pp., 1983, $45.

Equilibria, Nonequilibria, and Natural Waters, 2 vols., R. M. Pytkowicz (Ed.), John Wiley, New York; vol. 1, xv + 351 pp.; vol. 2, xv + 353 pp.; 1983, $49.95 each.

Groundwater Bibliography, F. van der Leeden, Geraghty & Miller, Syosset, New York, viii + 400 pp., 1983, $16.

Hydraulic Fracturing and Geothermal Energy, S. Nemat-Nasser, H. Abe, S. Hirakawa (Eds.), Martinus Nijhoff, Boston, xi + 528 pp., 1983, $78.50.

Ice Core Samples from Greenland and Antarctica, Ice Core Storage Facility and Information Exchange, SUNY Buffalo, New York, 49 pp.

Dam Safety Research Coordination Conference, Research Subcommittee of Interagency Committee on Dam Safety, Washington, D. C., 1983.

The International Field Year for the Great Lakes, E. J. Aubert and T. L. Richards (Eds.), National Oceanic and Atmospheric Administration, Ann Arbor, xi + 410 pp., 1983.

It Began with a Stone: A History of Geology From the Stone Age to the Age of Plate Tectonics, H. Faul and C. Faul (Eds.), John Wiley, New York, xvii + 270 pp., 1983, $38.95.

Kinetics and Equilibrium in Mineral Reactions, S. K. Saxena (Ed.), Springer-Verlag, New York, x + 273 pp., 1983, $39.80.

The Major Biogeochemical Cycles and Their Interactions, B. Bolin and R. B. Cook (Eds.), John Wiley, New York, xxi + 532 pp., 1983, $74.95.

*Man, A Geomorphological Agent*An Introduction to Anthropic Geomorphology, D. Nir, boren (Ed.), D. Riedel, Boston, xii + 165 pp., 1983, $45.50.

Metal Pollution in the Aquatic Environment, U. Forstner and G. T. W. Wittman (Eds.), Springer-Verlag, New York, 1983, $29.

The Phanerozoic Geology of the World, M. Moullade and A. E. M. Nairn (Eds.), Elsevier, New York, x + 450 pp., 1983, $12.75.

The Physics and Chemistry of Color: The Fifteen Causes of Color, John Wiley, New York, xx + 454 pp., 1983, $43.95.

Practical Sedimentology, D. W. Lewis, Hutchinson Ross, Stroudsburg, Pa., ix + 229 pp., 1984.

Principles of Aquatic Chemistry, F. M. M. Morel, John Wiley, New York, ix + 446 pp., 1983, $49.95.

Social Science Research and Climate Change: An Interdisciplinary Appraisal, R. S. Chen, E. Boulding, S. H. Schneider (Eds.), D. Riedel, Boston, viii + 255 pp., 1983, $43.50.

Solar-Terrestrial Physics: Principles and Theoretical Foundations, R. L. Carovillano and J. M. Forbes (Eds.), D. Reidel, Boston, xvii + 858 pp., 1983, $155.

Statistical Methods in Geology for Field and Lab Decisions, R. F. Cheeney, George Allen & Unwin, Boston, xvi + 169 pp., 1983, $25.

Terrigenous Clastic Depositional Systems: Applications to Petroleum, Coal, and Uranium Exploration, W. E. Galloway and D. K. Hobday (Eds.), Springer-Verlag, New York, xv + 423 pp., 1983, $39.

The Thunderstorm in Human Affairs, E. Kessler (Ed.), University of Oklahoma Press, Norman, 1983, $24.95.

Topics in Ocean Physics, Proceedings of the International School of Physics "Enrico Fermi," Course 80, Italian Physical Society, A. R. Osborne and P. M. Rizzoli (Eds.), North-Holland, New York, xv + 550 pp., 1982, $100.75.

Classified

POSITIONS AVAILABLE

The College of William and Mary/Physics Faculty Position. [illegible] Preference will be given to applicants [illegible] Please send vita and [illegible] Chairman, Search Committee, Physics Department, College of William and Mary, Williamsburg, Virginia 23185.

William and Mary is an affirmative action, equal opportunity employer. Women and minority applicants are encouraged to apply.

Senior Research Associate in Astrophysics/Lunar and Planetary Laboratory, University of Arizona. Applications are invited for a Senior Research Associate position in planetary astronomy at the Lunar and Planetary Laboratory, University of Arizona, in Tucson, Arizona. The position will involve the analysis of low resolution EUV and FUV stellar spectra obtained from the Ultraviolet Spectrometers on board the Voyager 1 and 2 spacecraft. Applicants are expected to have a doctoral degree and at least two years' experience in analysis of stellar data. A background in planetary atmospheres and familiarity with interactive computing are also desirable. Candidates should submit a letter of application with vita, bibliography and three letters of reference by January 30, 1984, to Dr. A. L. Broadfoot, Lunar and Planetary Laboratory, University of Arizona, 3625 E. Ajo Way, Tucson, Arizona 85713.

The University of Arizona is an equal opportunity employer.

Texas A&M University/Geological Oceanography Positions. The Ocean Drilling Project (ODP) invites application for the following anticipated positions. Several full-time staff scientists (Ph.D. required). These openings, in various fields of marine geoscience, are anticipated to be filled over a one year period commencing 1 October 1983. The successful candidates will be expected to participate approximately two months per year aboard a scientific drillship. These individuals will be responsible for coordinating activities prior and subsequent to the cruises, including the publication of results. The successful candidates will be expected to attend the JOIDES panel meetings relating to their scientific expertise. Several full-time marine technicians. Previous shipboard experience and undergraduate degree in geology or related science highly desirable. These positions require participation of about 6 months per year (alternating two months on and two months off) aboard a scientific drillship charter.

Applicants should submit a letter of application, curriculum vitae and names of 3 references to: Dr. Philip D. Rabinowitz, Project Director, ODP, Dept. of Oceanography, Texas A&M University, College Station, TX 77843.

Texas A&M University is an Equal Opportunity Employer.

Planetary Geologist/Brown University. Tenure track Assistant to Associate Professor position starting July 1, 1984, or as soon as possible thereafter to teach and conduct research in planetary geologic processes on Earth and other planets. Research should be on understanding the physical processes (for example, impact cratering, volcanism, tectonism) responsible for the origin of planetary surfaces. Applicants must have Ph.D. in planetology, geophysics or geology. Deadline for application is March 1, 1984. Interested parties should send vita and names of at least three persons we may contact for recommendations to: M.J. Rutherford, Chairman, Department of Geological Sciences, Brown University, Providence, RI 02912.

An equal opportunity/affirmative action employer.

University of Iowa/Faculty Positions. The Department of Physics and Astronomy anticipates two openings for tenure-track assistant professors or visiting faculty at any level in August 1984. In exceptional cases a term or tenured appointment at the associate professor or professor level will be considered. Preference for one position will be given to an experimentalist in intermediate or high energy physics. Current research interests in the department are radio and optical astronomy and the following specialties in physics: atomic, condensed matter, elementary particle, laser, nuclear, plasma, and space physics. Faculty duties include undergraduate and graduate teaching, guidance of research students and personal research. Interested persons should submit a resume and a statement of research interests and arrange for three letters of recommendation to be sent to Search Committee, Department of Physics and Astronomy, The University of Iowa, Iowa City, IA 52242.

The University of Iowa is an equal opportunity/affirmative action employer.

Seagoing Science Office/Research Assistant. Applications are invited for a position as Science Officer in Ship Operations at the College of Oceanography, Oregon State University. The following duties are to be performed, with the aid of one full-time assistant and a number of specialized technicians: (1) to provide the interface, both on land and at sea, between the Marine Facility and scientific project personnel carrying out shipboard research programs, and (2) to assume responsibility for the care of common-use equipment.

Approximately 240 days at sea are to be shared with the assistant. Qualifications include experience at sea, experience with electronics and computers, and a Bachelor's degree. Salary is $25,000/year plus $25/day sea pay. Start date is 1 March 1984. To apply, send resume with names and addresses and telephone numbers of three employment references by 31 January, 1984 to:

Ship Operations Office
College of Oceanography
Oregon State University
Corvallis, OR 97331.

Oregon State University, an Affirmative Action/Equal Opportunity Employer, complies with Section 504 of the Rehabilitation Act of 1973.

University of Arizona/Postdoctoral Research Position in Planetary Atmospheres. Applications are invited for postdoctoral research positions at the Lunar and Planetary Laboratory, University of Arizona, in Tucson, Arizona. The two positions will involve research in planetary physics and analysis of UV data from the Voyager mission. Research opportunities for these positions include the bound and extended atmospheres and ionospheres of the giant planets and their satellites, the Io plasma torus, earth's atmosphere, the interstellar medium, and the atmosphere and ionosphere of Venus. Applicants should have a strong background in theory and data analysis. Physicists and astronomers are encouraged to apply. Curriculum Vitae, bibliography and three letters of reference should be sent by March 1, 1984 to Dr. A. L. Broadfoot, Lunar and Planetary Laboratory, University of Arizona, 3625 E. Ajo Way, Tucson, Arizona 85713.

The University of Arizona is an Equal Opportunity Employer.

Faculty Positions/SUNY Stony Brook. The Department of Earth and Space Sciences, invites applications for a tenure-track faculty appointment. Rank and salary will be dependent on qualifications. The successful applicant must have research experience and an interest in teaching graduate and undergraduate students. Area of specialization are open since we are looking primarily for high-caliber applicants, but preference will be given to applicants with research interests in the areas of sedimentary geology and fluid-rock interactions which complement those of the existing program.

Qualified persons should send a resume with the names of three references to: Prof. William J. Meyers, Dept. of Earth and Space Sciences, SUNY Stony Brook, Stony Brook, NY 11794.

SUNY Stony Brook is an equal opportunity/affirmative action employer. AK038.

Oceanography/FSU. Assistant Professor in Marine Chemistry or Biogeochemistry, Chemical Sedimentology or Atmospheric Geochemistry. Applications invited for position starting with 1984–85 academic year. Contact by 1 March 1984: Chemical Oceanography Search Committee, Department of Oceanography, Florida State University, Tallahassee, FL 32306, Telephone: 904-644-6705.

We are an equal opportunity employer.

Computer Programming and Research Support. Science Systems and Applications, Inc. (SSAI) is seeking responsible applications oriented Scientists/Programmers/Engineers to provide systems software and hardware support services. Applicants must have DS/MS/PhD degree(s) and demonstrated experience in scientific programming (FORTRAN) and results analysis with large scale numerical simulations on mainframe (IBM) and supermini (Digital VAX) computers. These positions are located in metropolitan Washington, D.C. area. The projects areas involve satellite remote sensing, meteorology, agroclimatic environmental/monitoring and research in atmospheric sciences and geophysics. The positions vary from junior programmer, senior analyst/programmer to senior research scientist(s). SSAI provides a congenial academic work environment, pays bonuses and provides competitive salaries. Send your resume with salary history and references to: SCIENCE SYSTEMS AND APPLICATIONS, INC., 10210 Greenbelt Road, Suite 640, Seabrook, MD 20706.

University of Colorado-Boulder—Tenure Track Position in Atmospheric Dynamics. The Department of Astrophysical, Planetary and Atmospheric Sciences (formerly Astro-Geophysics) invites applications for a tenure track faculty position in the field of atmospheric science. The successful applicant must have a Ph.D. degree and should possess a strong background in geophysical fluid dynamics or dynamic meteorology, preferably in modeling large-scale terrestrial and/or planetary circulations. The appointment will be at the assistant professor level (although the associate professor level is not ruled out) and will begin August 29, 1984.

Applicants should have a strong commitment to research and to teaching at the graduate and undergraduate level. The opportunity will exist for a formal association with the Laboratory for Atmospheric and Space Physics, which has ongoing programs of space observations of planetary atmospheres.

To apply, please send a curriculum vita and the names and addresses of three references to:

Professor Gary E. Thomas
Department of Astrophysical, Planetary and Atmospheric Sciences
Campus Box 391
University of Colorado
Boulder, CO 80309
Telephone: 303-492-8915.

Salary: $24,000 minimum.

Application deadline: Postmarked no later than March 15, 1984. (Later applications will be accepted if the position is not filled.)

The University of Colorado is an equal opportunity/affirmative action employer.

Geophysics/Oregon State University. [illegible]

University of Arkansas/Tenure-Track Position—Structural Geology. [illegible]

Seismologist/University of Leeds(UK). [illegible]

University of Georgia/12-month tenure-track faculty appointment in The School of Forest Resources. [illegible]

SUNY-Albany/Tenure-Track Position in Tectonics or Structural Geology. [illegible]

Structural Geologist/Geophysicist/University of Wisconsin—Eau Claire. [illegible]

Summer Assistantships/National Astronomy and Ionosphere Center. [illegible]

University of Oklahoma/Electronics Instrumentation Specialist. [illegible]

Applied Geophysics/Bowling Green State University. [illegible]

University of Washington/Geophysics—Research Faculty Positions. [illegible]

Research in Space Plasmas, Solar and Heliospheric Physics. [illegible]

Water Resources Engineer/Hydrologist Faculty Position. [illegible]

Staff Scientist/JPL. [illegible]

Microprobe Technician-Operator/University of Maine at Orono. [illegible]

Center for Ocean-Land-Atmosphere Interactions: Department of Meteorology, University of Maryland, College Park, MD. [illegible]

University of Hawaii/Marine Geophysics. [illegible]

Atmospheric Scientist/University of Virginia. [illegible]

Geophysics-Tectonophysics/University of Wyoming. [illegible]

Structural Geologist/University of Maryland. [illegible]

Marine Geologist or Physical Oceanographer/Eckerd College [Florida]. [illegible]

Middlebury College/Sedimentary Geologist. [illegible]

Geophysicist Position/University of Colorado, Boulder. [illegible]

STUDENT OPPORTUNITIES

Graduate Research Assistantships in Geophysics/Michigan Technological University. [illegible]

SERVICES, SUPPLIES, COURSES, AND ANNOUNCEMENTS

Scanning Electron Microscopy and X-ray Microanalysis/Lehigh University. June 11–15, 1984. [illegible]

AGU

1983 Robert E. Horton Award

David A. Woolhiser

Citation

The recipient of this year's American Geophysical Union Robert E. Horton Award is David A. Woolhiser of the U.S. Department of Agriculture's Agricultural Research Service. Dr. Woolhiser is Supervisory Research Hydraulic Engineer and Research Leader for Watershed Hydrology at the Southwest Rangeland Watershed Research Center in Tucson, Arizona. His academic training was at the University of Wisconsin, where he received degrees of Bachelor of Science and Doctor of Philosophy, both in Civil Engineering, and at the University of Arizona, where he received an M.S., also in Civil Engineering.

Dr. Woolhiser's career has spanned government and academia and his contributions to hydrology have ranged from theoretical developments to practical applications.

He has more than 20 years of service with the U.S. Department of Agriculture and has been on the faculties of Cornell University, Colorado State University, and the University of Arizona. He is very active in the American Geophysical Union, the American Society of Civil Engineers, and the American Society of Agricultural Engineers.

Dave's first major contribution to scientific hydrology was an accurate solution to the shallow water equations with boundary conditions appropriate for overland flow. His derivation of a nondimensional kinematic flow number set forth a criterion for when the kinematic wave formulation can be used in place of the complete flow equations.

This initial contribution was extended in a number of important directions that led to the development of the kinematic overland flow model into an important hydrological tool. Dave collaborated in obtaining the first solutions to the combined overland flow and infiltration problem, utilizing a partial differential equation formulation for both phenomena. Additional developments include numerical methods to solve the kinematic wave equations, the formulation and solution of overland flow for converging surfaces, development of a kinematic cascade for surface runoff, and the formulation of a nonlinear kinematic wave model for overland flow.

Dave has also made important contributions in the application of the kinematic overland flow model to real-world problems.

A major outgrowth of Dave's overland flow research is a better understanding of the impact of spatial variability in catchment parameters on the outflow hydrograph and his pioneering work in nonpoint loadings.

The impact of Dave's contributions can be measured by the role kinematic modeling has in hydrology today. Virtually every graduate hydrology curriculum has a course in kinematic modeling. The U.S. Geological Survey's Distributed Routing Rainfall Runoff Model is based upon kinematic overland and channel flow equations and the U.S. Army Corps of Engineer's STORM model has a kinematic model component. The kinematic model is a widely accepted tool in hydrologic consulting.

Thus, it is with great pleasure that I present the 1983 AGU Robert E. Horton Award to Dr. David A. Woolhiser, a scientist and civil servant of the highest merit.

Peter S. Eagleson
President
AGU Hydrology Section

Acceptance

It is a great pleasure to receive this award. Upon reflecting on my research career in hydrology, it is clear to me that chance and privilege have played a major role leading to this occasion.

Because chance plays such an important part in hydrologic phenomena, it is, perhaps, appropriate that I entered the field by chance. In my undergraduate program at the University of Wisconsin, I concentrated on the structural option in the Agricultural Engineering Curriculum. I did take one course in hydrology, and wrote a B.S. thesis on a hydrologic topic, but I must admit that I really was not particularly excited about the subject. When graduation time came, however, my job offers were both for hydrologic research positions. I accepted a position as instructor with the Agricultural Engineering Department at the University of Arizona, and started work on July 1, 1955, installing raingages and surveying reservoirs at the Atterbury Reservoir Watershed east of Tucson, Arizona. During the course of the 3 years that I was associated with this project, I became fascinated with the challenges associated with describing surface runoff phenomena in semiarid regions. It became clear to me that distributed rainfall and runoff models were essential in this regard, and so my career goals were established.

I have been privileged in many ways. First, it has been my privilege to be active in hydrologic research at a time when developments in technology, especially computer technology, made it possible to carry out analyses and to propose models that simply were not feasible before. For example, the works by Lighthill and Whitham and Iwagaki on kinematic waves were published in 1955, and finite difference techniques were just beginning to be applied to problems in flood routing and hydraulics. My work on the kinematic wave was a natural extension of this and other work. In fact, had computers been available in 1937, Merrill Bernard probably would have developed a distributed model of surface runoff quite similar to those developed in the last decade.

Second, it has also been my privilege to work with a talented group of colleagues. Their contributions, directly or indirectly, cannot be properly acknowledged. However, I would like to name a few, while apologizing to the many left unmentioned. During my stay at Madison and Columbia, Missouri, Neal Minshall impressed upon me the importance of taking great care in collecting hydrologic data and the need to always check the instruments and the calculations. Jim Liggett, at Cornell University, suggested our collaboration in the finite difference solution of the shallow water equations, thus inaugurating a very exciting and productive period of research.

I found the environment at Colorado State University to be very stimulating. With people like V. M. Yevjevich, D. B. Simons, H. J. Morel-Seytoux, P. Todorovic, H. W. Shen, D. Dawdy, J. Salas, my ARS colleagues H. Duke, G. Kruse, and P. E. Smith, and an outstanding USGS group in the early days, as well as the many visiting faculty, there were many exciting ideas going around. My collaboration with Petar Todorovic in the stochastic description of daily precipitation and flood phenomena was particularly beneficial in that it gave me a better appreciation for what can be achieved by purely analytic methods as opposed to simulation techniques. As a full-time researcher with ARS, but with offices at the CSU Engineering Research Center, I probably had the best of both worlds—the benefit of daily contact with faculty and students without the daily demands of teaching and university committee activities.

Third, it has been my privilege to work with an outstanding group of graduate students. Working with them has been the most satisfying aspect of my career. Several have gone on to become prominent in hydrologic research or teaching, including Dave Kibler, Roger Smith, Vijay Singh, and Leonard Lane, to mention a few.

Finally, I would like to express my appreciation to my agency, the Agricultural Research Service of the U.S. Department of Agriculture. Although our research mission is an applied one, our managers recognize that practical applications are often hampered by theoretical problems, and that individual researchers require considerable freedom to choose areas of research.

To my colleagues, former students, the many aides and technicians who gathered experimental watershed data, and to the secretaries who typed barely legible papers, I would like to dedicate this award. This honor would not have been possible without you.

David A. Woolhiser

Meetings

Announcements

Magmatic Evolution

August 22–26, 1984 Field Conference on Open System Behavior in Magmatic Evolution: Petrological, Geochemical, and Geophysical Constraints, Taos, N. Mex. Sponsor, Institute for the Study of Earth and Man (ISEM). Information contact: Mike Dungan, Department of Geological Sciences, Southern Methodist University, Dallas, TX 75275; telephone 214-692-2750.

The conference will examine models of open system magmatism in the light of thermal, fluid dynamic, petrologic, geochemical, and isotopic considerations. Included on the schedule are afternoon field trips to volcanic areas near Taos, and morning and evening symposium sessions on such processes as magma mixing and crustal contamination in layered basaltic intrusions, batholiths, and volcanic rocks. Other topics will include physical and chemical constraints on the nature of magma chambers, mechanisms of magma migration, and general geochemical modeling techniques.

The application deadline for the conference is February 25, and extended abstracts are due May 1.

The Geophysical Year calendar last appeared in the December 6, 1983, issue.

GAP

Separates

To Order: The order number can be found at the end of each abstract; use all digits when ordering. Only papers with order numbers are available from AGU. ***Cost:*** $3.50 for the first article and $1.00 for each additional article in the same order. Payment must accompany order. Deposit accounts available.

Send your order to:
American Geophysical Union
2000 Florida Avenue, N.W.
Washington, DC 20009

Aeronomy

Electromagnetics

Exploration Geophysics

Geochemistry

Geomagnetism and Paleomagnetism

Hydrology

Meteorology

Oceanography

Journal of Geophysical Research
Volume 89 Number C1 January 20, 1984